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relative order of the sub-faunas, the record agrees, in general, with that of the series exposed along the same meridian, farther north, in New-York state. The principal difference which strikes one familiar with the New-York section is the appearance of *S. disjuncta* and *O. Tioga* lower down in the faunas in the southern sections.

But although heretofore *S. disjuncta* has been met with in America only in the middle and upper parts of the upper Devonian, in Devonshire we find it reported from the middle Devonian, with corals and trilobites in abundance; and in northern Europe it begins at least as early as the base of the upper Devonian.

While it is beyond doubt that even in New-York state the three spirifers mentioned appear mingled at various zones in the upper Devonian, we do not question the fact that the periods of abundance for each species are in separate zones, and assume a regular sequence relative to each other.

HENRY S. WILLIAMS.

Cornell university.

The use of the method of limits in mathematical teaching.

Rice and Johnson's 'Method of rates' is especially to be commended for the scholarly manner in which they developed the subject; but there is the same difficulty in the fundamental conception as in the infinitesimal method. One may assume to understand an expression with which he is familiar until closely questioned. A student learns to repeat with ease, 'Velocity is rate of motion,' and thinks he understands it; but I have had many such ask, 'In a mathematically perfect engine, does the piston stop at the end of the stroke?' 'Does it remain at rest at any time?' 'How can it reverse its motion, if it does not stop?' 'How can it cease going in one direction, and move in the opposite direction, without stopping between the two motions?' These are critical questions, lying at the very foundation of all change of motion. Does change in the rate of motion take place at an instant, or during an instant?

The method of limits leads the mind towards a result the conclusions of which it is impossible to escape: hence, as a system of philosophy, it retains its strong hold.

DE VOLSON WOOD.

Hoboken, March 16.

Ropes of ice.

On Saturday, March 8, while traversing several counties of southern Ohio by railroad, I observed an illustration of the viscosity of ice, that seems deserving of mention.

For a number of hours, rain had been falling, much of it freezing as it fell; but through the day the temperature rose slightly, remaining, however, close to the freezing-point. All exposed objects were coated with ice. In particular, telegraph-wires and the strands of wire fences were heavily loaded. In the afternoon the ice broke loose from the wires at innumerable points, hanging from them in depending curves, the fixed points of which were sometimes as much as six or eight feet apart, and the lowest points of the curves from two to twelve inches below the wires. Occasionally the curves would break, and the ends of the ice rope, two or three feet in length, would project downwards from the wires at an angle of forty-five degrees or more.

The best examples were passed without opportunity

to make examination, but all of the facts were illustrated at the stations where the train stopped.

E. O.

Illusive memory.

I merely intended, in my letter of March 7, to present two of the most prevalent theories which have been advanced for these illusions. The 'race memory' theory, kindly brought out by W. B. T., should perhaps have been mentioned, as well as the theory of Lewes and Ribot, that these deceptions arise from the retrojection or false location of a *present* mental image as a recollection. The inheritance of the actual *cerebral impressions* of a former generation rests upon no scientific basis. We do inherit the brain structure, and, in so far as brain functions are dependent upon structure, we may be said to inherit certain functional disposition and powers; but this structure, and the impressions made upon it by sense-perception, are essentially different facts.

The correspondence invited should be addressed to Princeton, N.J., instead of Princeton, N.Y., as was wrongly given in *Science*, No. 57.

HENRY F. OSBORN.

Princeton, N.J., March 21.

Ripple-marks.

Professor Wooster's note in No. 57, on ripple-marked limestones in Kansas, recalls an observation of my own in Utah. In the south part of that territory the Jurassic formation includes a scutell limestone fifteen to twenty-five feet in thickness, containing remains of *Camptonectes* and *Pentacrinus*. Some of the surfaces of the layers exhibit coarse ripple-marks, the wave-lengths ranging from six inches to one foot. The associated fossils cannot be regarded in this case as indicative of quiet conditions, for in neighboring districts the same forms are found in argillaceous sandstones. In the sandstones the shells and crinoid segments exhibit wear from rolling, but in the limestone their angles are unimpaired. While, however, there is no evidence in the limestone of violence, there is evidence of motion. The crinoids have not been found entire, and all their segments are usually detached. Moreover, the structure of some of the limestone layers is oolitic.

I conceive that the association of ripple-marks with shallow water, while usual, is not invariable. The most important condition for the formation of ripple-marks is motion; and any thing competent to produce motion at the bottom of deep water may form them. Wind-waves on the Atlantic are said to have brought sand to the surface from a depth of five hundred feet, and they must be supposed to produce at a still greater depth the gentler agitation necessary for the formation of ripple-marks.

The association of the Kansas ripple-marks with fine argillaceous rocks is perhaps unprecedented, but there seems no theoretic reason to regard it with wonder. Fine sediment does not usually come to rest in spots where the water is subject to agitation, but exceptionally it does; and the centre of every shallow pond with a muddy bottom affords an illustration. Some years ago I observed ripple-marks on a surface of fine river-silt at the bottom of a pool which had communication with a rushing river. The pulsation of the torrent communicated agitation to the pool, but no current; and I inferred that the pulsatory agitation caused the rippling. The pool shared to some extent the muddiness of the river, and the silt on its bottom was evidently a forming deposit. Not far away the bank of the same river exhibited in section

a deposit which seemed identical with that forming in the pool, the ripple-marks being represented by undulations of the laminae. A remarkable feature of the section was the coincidence of the ripples through a vertical space of about eighteen inches. All the laminae were inflected in the same way, so that the corresponding parts of the undulations fell in the same verticals, as illustrated in fig. 1.

It occurred to me, that there might be in this feature something analogous to the assumption of stable

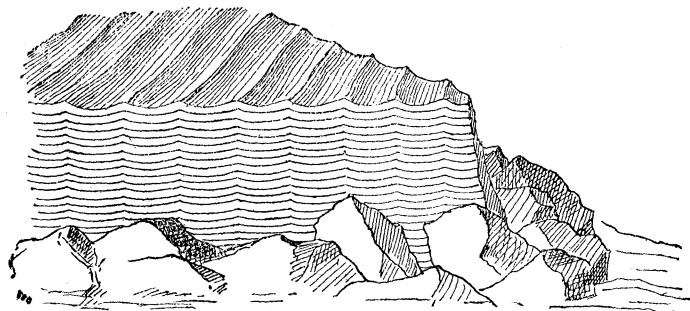


FIG. 1.

figures by free particles on the surface of a vibrating plate, and that the development of this idea might lead to a better theory of the origin of ripple-marks. The common theory, which makes the ripple-mark the homologue of the sand-dune, implies a forward movement of the ripple in the direction of the water-current, and is manifestly inapplicable to the phenomenon just described. I am disposed to doubt its applicability even to ripple-marks produced by currents; for there is a certain class of these, intimately related to small obstructions, which are certainly as stationary and constant as the water-waves on the rapid of a stream.

The analogy of ripple-marks to vibrations in elastic

fully drawn from hand specimens. Figs. 2 and 3 are the prevalent forms. In fig. 3 the crest is acute, and the broadly curved trough is midway between the crests. In fig. 2 the crest and trough are moderately acute, and the trough is nearer to one crest than to the other. In fig. 4 the crest is broadly curved, and the trough is less so. In fig. 5 each ripple has a subsidiary crest upon one slope. The resemblance of this last to certain phonographic curves suggests itself at once. In other specimens two systems of ripples co-exist, intersecting at various angles; and the fact that this relation was observed repeatedly, leads me to think that the two sets were synchronously formed. If synchronously formed, there is something in their production analogous to the co-existence of independent and diverse vibrations in elastic bodies.

I do not venture to assert that the correspondences here pointed out are more than superficial analogies, but they suggest a line of investigation which should be fruitful. Such investigation I had intended to undertake, and the accompanying figures were engraved in pursuance of this intention; but, having

found myself for some years unable to pursue the subject, I despair of commanding the necessary time and facilities, and avail myself of this opportunity to communicate my observations to the scientific public, in the hope that they may assist in the elucidation of the subject by another.

G. K. GILBERT.

The 'Batrachichthys.'

The publication of the *Archivos do museu nacional* of Brazil began in Rio de Janeiro in 1876. In the second issue, that for the second and third trimesters of 1876, the director of the section of zoölogy and comparative anatomy in the museum published a descrip-



FIG. 2. — Natural size.



FIG. 3. — Two-thirds natural size.



FIG. 4. — Natural size.



FIG. 5. — Natural size.

bodies is further illustrated by variations in the forms of the ripples, and by the combination of sets of ripples. The other figures show in profile four forms of ripple observed on upper surfaces of triassic sandstone in south-western Utah. They were care-

tion of what he denominated 'an extremely curious little animal called *Batrachichthys*' The author evidently believed he had found a 'missing link,' and, as it were, he laid his prize at the feet of Darwin, Haeckel, and Martius with the greatest solemnity.